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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 92-16

"CCITT TEST DOCUMENTS" DIGITIZATION

JUNE 1993

OFFICE OF THE MANAGER
NATIONAL COMMUNICATIONS SYSTEM
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Stephen Perschau

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Delta Information Systems, Inc.
300 Welsh Road, Building #3
Horsham, PA 19044-2273

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The purpose of this report was to scan the "eight Consultative Communication for International Telegraph and Telephone (CCITT) test documents" at pel densities of 200, 300, 400 and 600 pels per inch, compress the data, and store them on DOS diskettes. Eight documents were originally digitized by the French Administration, and were used in the Group 3 Facsimile algorithm selection process, completed in 1980. These images are often referred to as the "CCITT standard images." Although they were never an official standard, they have been used extensively by experimenters over the years. They were scanned at roughly 200 pels per inch, consistent with the capabilities of facsimile machines at that time. Recently there has been renewed interest in these images. Many of the inquiries for these images have been for digitized images of DOS diskette media at pel densities higher than 200 pels per inch. The NCS has been a leader in the development and promulgation of standardized imagery for facsimile. The NCS has sponsored the digitizing of documents at resolutions of 200, 240, 300, 400, and 480 lines per inch. This data has been used my many experimenters in the development of standard compression algorithms for digital facsimile.

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1. INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc. (DIS) for the National Communications System (NCS), Office of Technology and Standards. This office is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies. The purpose of this project, ~~performed under contract number DCA100-91-C-0031,~~ was to scan the "eight CCITT test documents" at pel densities of 200, 300, 400 and 600 pels per inch, and store them on DOS diskettes.

~~The~~ eight documents were originally digitized by the French Administration, and were used in the Group 3 Facsimile algorithm selection process, completed in 1980. These images are often referred to as the "CCITT standard images". Although they were never an official standard, they have been used extensively by experimenters over the years. They were scanned at roughly 200 pels per inch, consistent with the capabilities of facsimile machines at that time.

Recently there has been renewed interest in these images, including a proposal in the CCITT that they be made an official standard (recommendation). Many of the inquiries for these images have been for digitized images on DOS diskette media at pel densities higher than 200 pels per inch. Current Group 3 and Group 4 facsimile machines have up to 400 pel per inch capability, and the next step could easily be 600 pels per inch.

The NCS has been a leader in the development and promulgation of standardized imagery for facsimile. The NCS has sponsored the digitizing of documents at resolutions of 200, 240, 300, 400, and 480 lines per inch. This data has been used by many experimenters in the development of standard compression algorithms for digital facsimile, and has contributed significantly to the development of facsimile recommendations which will be of considerable value to the U.S. Government. In addition, the NCS sponsored the preparation of standard gray scale images, representative of continuous tone pictures to be transmitted through facsimile systems.

The purpose of this project was to scan the "eight CCITT test documents" at pel densities of 200, 300, 400 and 600 pels per inch, compress the data, and store it on DOS diskettes.

This report is comprised of three sections. Section 1 provides a brief description of the objectives of the study and an outline of the contents of this report. Section 2 discusses the steps taken to scan the images. Section 3 is a guide to expanding the images to their original size.

NCS TECHNICAL INFORMATION BULLETIN 92-16

"CCITT TEST DOCUMENTS" DIGITIZATION

JUNE 1993

PROJECT OFFICER

Stephen Perschau

STEPHEN PERSCHAU
Computer Scientist
Office of Technology
and Standards

APPROVED FOR PUBLICATION:

Dennis Bodson

DENNIS BODSON
Assistant Manager
Office of Technology
and Standards

FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents and overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
Attn: NT
701 S. Court House Road
Arlington, VA 22204-2198

"CCITT TEST DOCUMENTS"
DIGITIZATION

JUNE 1993

SUBMITTED TO:
THE NATIONAL COMMUNICATIONS SYSTEM
701 SOUTH COURT HOUSE ROAD
ARLINGTON, VA 22204-2198

DELTA INFORMATION SYSTEMS, INC.
300 WELSH ROAD, BUILDING 3
HORSHAM, PA 19044-2273
TEL: (215)657-5270 FAX: (215) 657-5273

TABLE OF CONTENTS

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2. TECHNICAL DISCUSSION

Figure 1 through Figure 8 illustrate the test documents that were scanned. The images used in the scanning process were obtained from SEPT[1]. They are from a set of original-quality copies made at the time that the Group 3 compression algorithm studies were being conducted. All of the images are A4 size, that is 210 mm wide by 297 mm long.

The resolutions selected for the scanning process (200, 300, 400, and 600 pels per 25.4 mm) were based on those specified in the Group 3 and Group 4 recommendations (200, 300, and 400 pels per 25.4 mm) plus 600 pels per 25.4 mm. The additional higher resolution anticipates the advancing laser printing technology.

Having selected the resolutions and given the width of the image, the number of pels per line can be determined. For the A4 page width of 210 mm, a 200 pels per 25.4 mm scan gives 1654 pels per line. The 1654 pel width is not a convenient number for computers (not divisible by 8). One way to correct this condition is to extend the right margin to make an even number of bytes, as the French PTT did when they originally scanned the images. A better approach would be to produce a digital image that closely approximates the image produced by a Group 3 or Group 4 facsimile scanner. The latter approach was chosen for this project; that is, the charts were scanned to produce the nominal pels per line and lines per image shown in the Group 3 and Group 4 Recommendations. This means that the documents were centered and overscanned. (The chart itself is 210 mm wide, but the scan line is 219.46 mm wide.) Figure 9 illustrates the scanning geometry for the four sampling densities. A reference point is defined that is just inside the top left corner of the image, 0.5 pels from the corner. The coordinates of the reference point, shown in pels, define the position of the A4-size image within the total digitized image. The blanking margin is white.

The images are scanned left-to-right and top-to-bottom, just as in facsimile.

---

[1] Mr. Grimault of Service d'Etudes communes de La Poste et de France Telecom graciously provided the images.

The scanning process was performed by the Image Electronics Center of Eastman Kodak on a microdensitometer. The microdensitometer samples each pel at 12 bits. The data is processed to produce one bit per pel, stored in the following way. The left-most (first) pel of the first scan line is stored in the most significant bit of the first byte. Proceeding from left to right, pels are stored in successive bytes, 8 pels to a byte, from most significant to least significant. A black pel is a "1" and a white pel is a "0".

THE SLEREXE COMPANY LIMITED

SAPORS LANE · BOOLE · DORSET · BH25 8ER

TELEPHONE BOOLE (945 13) 51617 · TELEX 123456

Our Ref. 350/PJC/EAC

18th January, 1972.

Dr. P.N. Cundall,
Mining Surveys Ltd.,
Holroyd Road,
Reading,
Berks.

Dear Pete,

Permit me to introduce you to the facility of facsimile transmission.

In facsimile a photocell is caused to perform a raster scan over the subject copy. The variations of print density on the document cause the photocell to generate an analogous electrical video signal. This signal is used to modulate a carrier, which is transmitted to a remote destination over a radio or cable communications link.

At the remote terminal, demodulation reconstructs the video signal, which is used to modulate the density of print produced by a printing device. This device is scanning in a raster scan synchronised with that at the transmitting terminal. As a result, a facsimile copy of the subject document is produced.

Probably you have uses for this facility in your organisation.

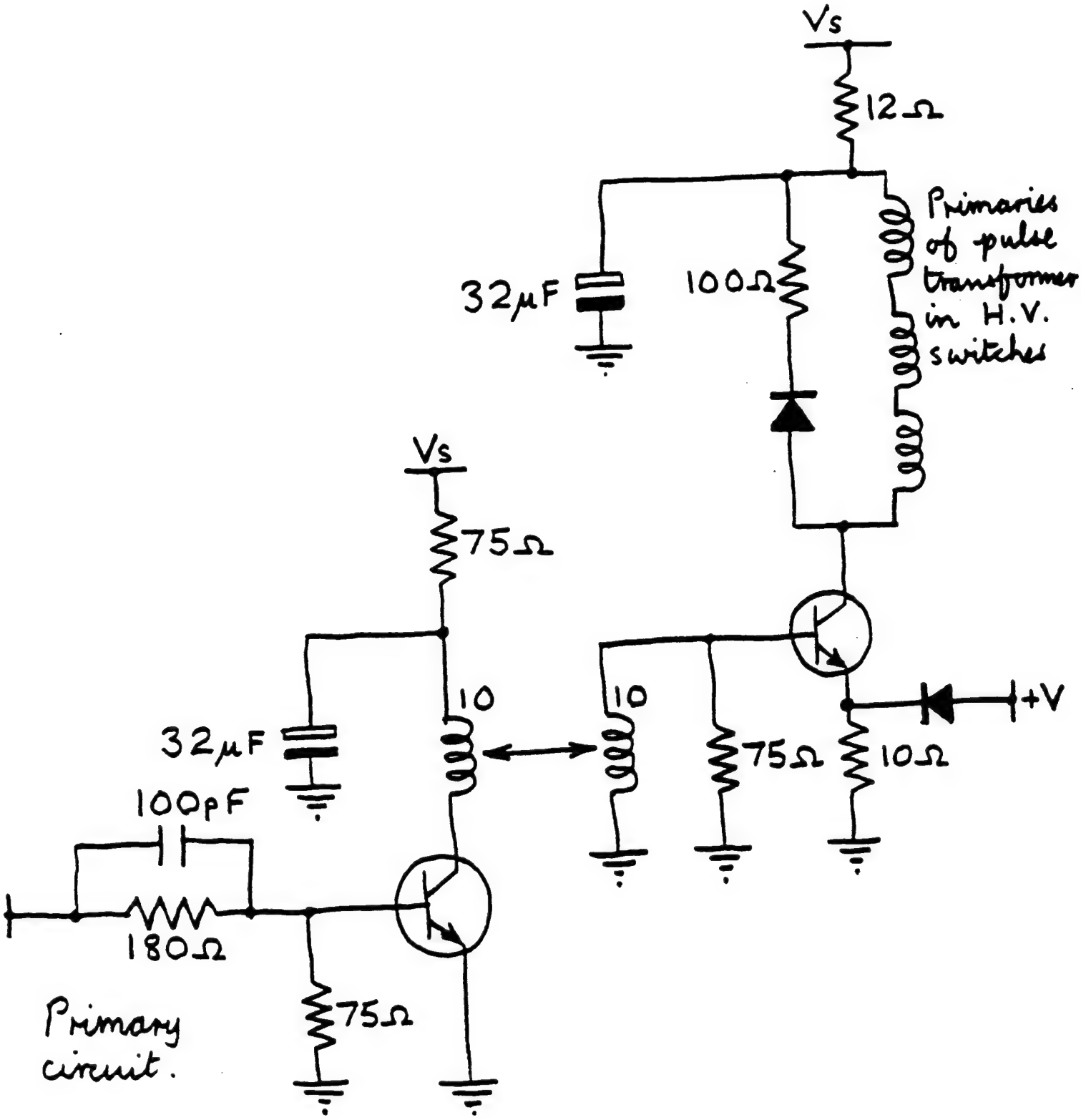
Yours sincerely,

Phil.

P.J. CROSS
Group Leader - Facsimile Research

FIGURE 1

Registered in England: No. 2038
Registered Office: 60 Vicarage Lane, Ilford, Essex.



This is current driver circuit.

Phil.

FIGURE 2

22-9-71

Mot directeur

ETABLISSEMENTS ABCDEFG
SOCIETE ANONYME AU CAPITAL DE 300 000 F
20, RUE DU XVUTRSTBSL F 00000 NTBCLAG
Tél. : (35) 24.46.32 Adr. Tg. : NRVLJROLM
Télex : 31596 F IN : 718490070257
Transporteur (ou Transitaire)
M. M. DUPONT Frères
8 quai des bicdfsh F 0000 NTBCLAG

CLASSEMENT	FACTURE INVOICE	Exemplaire 15	
CODE CLIENT Z 04399	DATE 7-7-74	NUMERO 06	FEUILLET 01

Votre commande du 74-2-2 numéro 438

Notre offre AZ/B7 du 74-1-1 numéro 12

LIVRAISON
5, rue XYZ
99000 VILLE

FACTURATION
12, rue ABCD BP 15
99000 VILLE

DOMICILIATION BANCAIRE DU VENDEUR

CODE BANQUE | CODE GUICHET | COMPTE CLIENT

PAYS D'ORIGINE | PAYS DE DESTINATION

CONDITIONS DE LIVRAISON | DATE 74-03-03

LICENCE D'EXPORTATION | NATURE DU CONTRAT (monnaie)

CONDITIONS DE PAIEMENT (échéance, %...) FAB

TRANSPORTS ORIGINE	DESTINATION	MODE
Pays 1	Etat 2	Air

MARQUES ET NUMEROS MARKS AND NUMBERS	NOMBRE ET NATURE DES COLIS : DENOMINATION DE LA MARCHANDISE NUMBER AND KING OF PACKAGES: DESCRIPTION OF GOODS	NOMENCLATURE STATISTICAL No.	MASSE NETTE NET WEIGHT / MASSE BRUTE GROSS WEIGHT	VALEUR VALUE / DIMENSIONS MEASUREMENTS
74.21.456.44.2 A	1 Composants	U 123/4	5 kg / 8 kg	1400 X 13x10x6

QUANTITE COMMANDEE ET UNITE QUANTITY ORDERED AND UNIT	N° ET REF. DE L'ARTICLE	DESIGNATION	QUANTITE LIVREE ET UNITE QUANTITY DELIVERED AND UNIT	PRIX UNITAIRE UNIT PRICE	MONTANT TOTAL TOTAL AMOUNT
2	AF-809	Circuit intégré	2	104,33 F	208,66 F
10	S8-T4	Connecteur	10	83,10 F	831,00 F
25	ZI07	Composant indéterminé	20	15,00 F	300,00 F

Costs	Débours	Inclus	Non inclus
Packing	Emballages		92,14
Freight	Transport		
Insurance	Assurances		
Invoice amount	Montant total de la facture		1431,80
Installment	Acomptes		
NET TO BE PAID	NET A REGLER		1431,80

FIGURE 3

L'ordre de lancement et de réalisation des applications fait l'objet de décisions au plus haut niveau de la Direction Générale des Télécommunications. Il n'est certes pas question de construire ce système intégré "en bloc" mais bien au contraire de procéder par étapes, par paliers successifs. Certaines applications, dont la rentabilité ne pourra être assurée, ne seront pas entreprises. Actuellement, sur trente applications qui ont pu être globalement définies, six en sont au stade de l'exploitation, six autres se sont vu donner la priorité pour leur réalisation.
Chaque application est confiée à un "chef de projet", responsable successivement de sa conception, de son analyse-programmation et de sa mise en oeuvre dans une région-pilote. La généralisation ultérieure de l'application réalisée dans cette région-pilote dépend des résultats obtenus et fait l'objet d'une décision de la Direction Générale. Néanmoins, le chef de projet doit dès le départ considérer que son activité a une vocation nationale donc refuser tout particularisme régional. Il est aidé d'une équipe d'analystes-programmeurs et entouré d'un "groupe de conception" chargé de rédiger le document de "définition des objectifs globaux" puis le "cahier des charges" de l'application, qui sont adressés pour avis à tous les services utilisateurs potentiels et aux chefs de projet des autres applications. Le groupe de conception comprend 6 à 10 personnes représentant les services les plus divers concernés par le projet,et comporte obligatoirement un bon analyste attaché à l'application.

II - L'IMPLANTATION GEOGRAPHIQUE D'UN RESEAU INFORMATIQUE PERFORMANT

L'organisation de l'entreprise française des télécommunications repose sur l'existence de 20 régions. Des calculateurs ont été implantés dans le passé au moins dans toutes les plus importantes. On trouve ainsi des machines Bull Gamma 30 à Lyon et Marseille, des GE 425 à Lille, Bordeaux, Toulouse et Montpellier, un GE 437 à Massy, enfin quelques machines Bull 300 TI à programmes câblés étaient récemment ou sont encore en service dans les régions de Nancy, Nantes, Limoges, Poitiers et Rouen ; ce parc est essentiellement utilisé pour la comptabilité téléphonique.
A l'avenir, si la plupart des fichiers nécessaires aux applications décrites plus haut peuvent être gérés en temps différé, un certain nombre d'entre eux devront nécessairement être accessibles, voire mis à jour en temps réel : parmi ces derniers le fichier commercial des abonnés, le fichier des renseignements, le fichier des circuits, le fichier technique des abonnés contiendront des quantités considérables d'informations.
Le volume total de caractères à gérer en phase finale sur un ordinateur ayant en charge quelques 500 000 abonnés a été estimé à un milliard de caractères au moins. Au moins le tiers des données seront concernées par des traitements en temps réel.
Aucun des calculateurs énumérés plus haut ne permettait d'envisager de tels traitements.
L'intégration progressive de toutes les applications suppose la création d'un support commun pour toutes les informations, une véritable "Banque de données", répartie sur des moyens de traitement nationaux et régionaux, et qui devra rester alimentée, mise à jour en permanence, à partir de la base de l'entreprise, c'est-à-dire les chantiers, les magasins, les guichets des services d'abonnement, les services de personnel etc.
L'étude des différents fichiers à constituer a donc permis de définir les principales caractéristiques du réseau d'ordinateurs nouveaux à mettre en place pour aborder la réalisation du système informatif. L'obligation de faire appel à des ordinateurs de troisième génération, très puissants et dotés de volumineuses mémoires de masse, a conduit à en réduire substantiellement le nombre.
L'implantation de sept centres de calcul interrégionaux constituera un compromis entre : d'une part le désir de réduire le coût économique de l'ensemble, de faciliter la coordination des équipes d'informaticiens; et d'autre part le refus de créer des centres trop importants difficiles à gérer et à diriger,et posant des problèmes délicats de sécurité. Le regroupement des traitements relatifs à plusieurs régions sur chacun de ces sept centres permettra de leur donner une taille relativement homogène. Chaque centre "gérera" environ un million d'abonnés à la fin du VIème Plan.
La mise en place de ces centres a débuté au début de l'année 1971 : un ordinateur IRIS 50 de la Compagnie Internationale pour l'Informatique a été installé à Toulouse en février ; la même machine vient d'être mise en service au centre de calcul interrégional de Bordeaux.

FIGURE 4

Photo n° 1 - Document très dense lettre 1,5mm de haut - Restitution photo n° 9

Cela est d'autant plus valable que $T\Delta f$ est plus grand. A cet égard la figure 2 représente la vraie courbe donnant $|\phi(f)|$ en fonction de f pour les valeurs numériques indiquées page précédente.

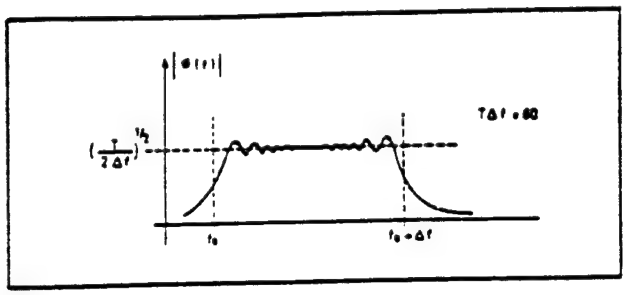


FIG. 2

Dans ce cas, le filtre adapté pourra être constitué, conformément à la figure 3, par la cascade :

— d'un filtre passe-bande de transfert unité pour $f_0 \leqslant f \leqslant f_0 - \Delta f$ et de transfert quasi nul pour $f < f_0$ et $f > f_0 - \Delta f$, filtre ne modifiant pas la phase des composants le traversant ;

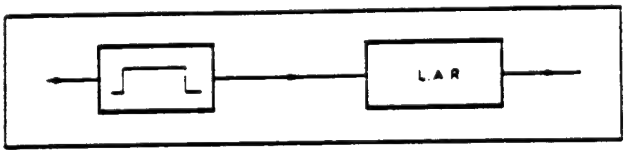


FIG. 3

— filtre suivi d'une ligne à retard (LAR) dispersive ayant un temps de propagation de groupe T_R décroissant linéairement avec la fréquence f suivant l'expression :

$$T_R = T_0 + (f_0 - f)\frac{T}{\Delta f} \quad (\text{avec } T_0 > T)$$

(voir fig. 4).

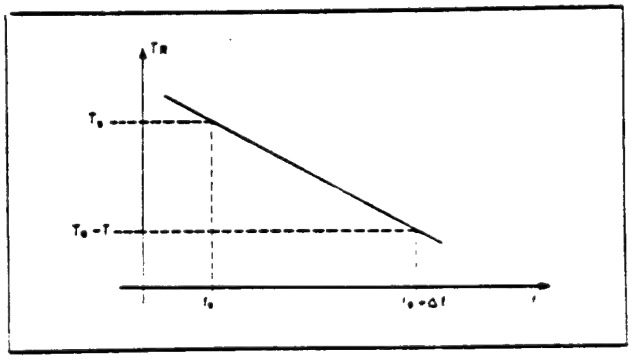


FIG. 4

telle ligne à retard est donnée par :

$$\varphi = -2\pi \int_0^f T_R \, df$$

$$\varphi = -2\pi \left[T_0 + \frac{f_0 T}{\Delta f} \right] f + \pi \frac{T}{\Delta f} f^2$$

Et cette phase est bien l'opposé de $\underline{/\phi(f)}$, à un déphasage constant près (sans importance) et à un retard T_0 près (inévitable).

Un signal utile $S(t)$ traversant un tel filtre adapté donne à la sortie (à un retard T_0 près et à un déphasage près de la porteuse) un signal dont la transformée de Fourier est réelle, constante entre f_0 et $f_0 + \Delta f$, et nulle de part et d'autre de f_0 et de $f_0 + \Delta f$, c'est-à-dire un signal de fréquence porteuse $f_0 + \Delta f/2$ et dont l'enveloppe a la forme indiquée à la figure 5, où l'on a représenté simultanément le signal $S(t)$ et le signal $S_1(t)$ correspondant obtenu à la sortie du filtre adapté. On comprend le nom de récepteur à compression d'impulsion donné à ce genre de filtre adapté : la « largeur » (à 3 dB) du signal comprimé étant égale à $1/\Delta f$, le rapport de compression est de $\dfrac{T}{1/\Delta f} = T\Delta f$

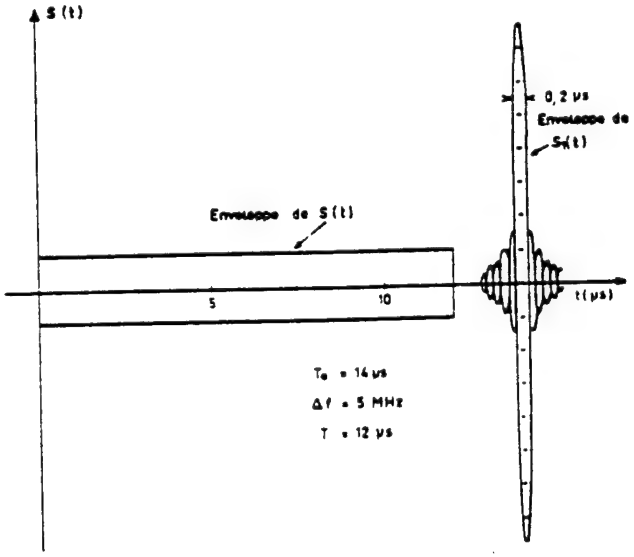
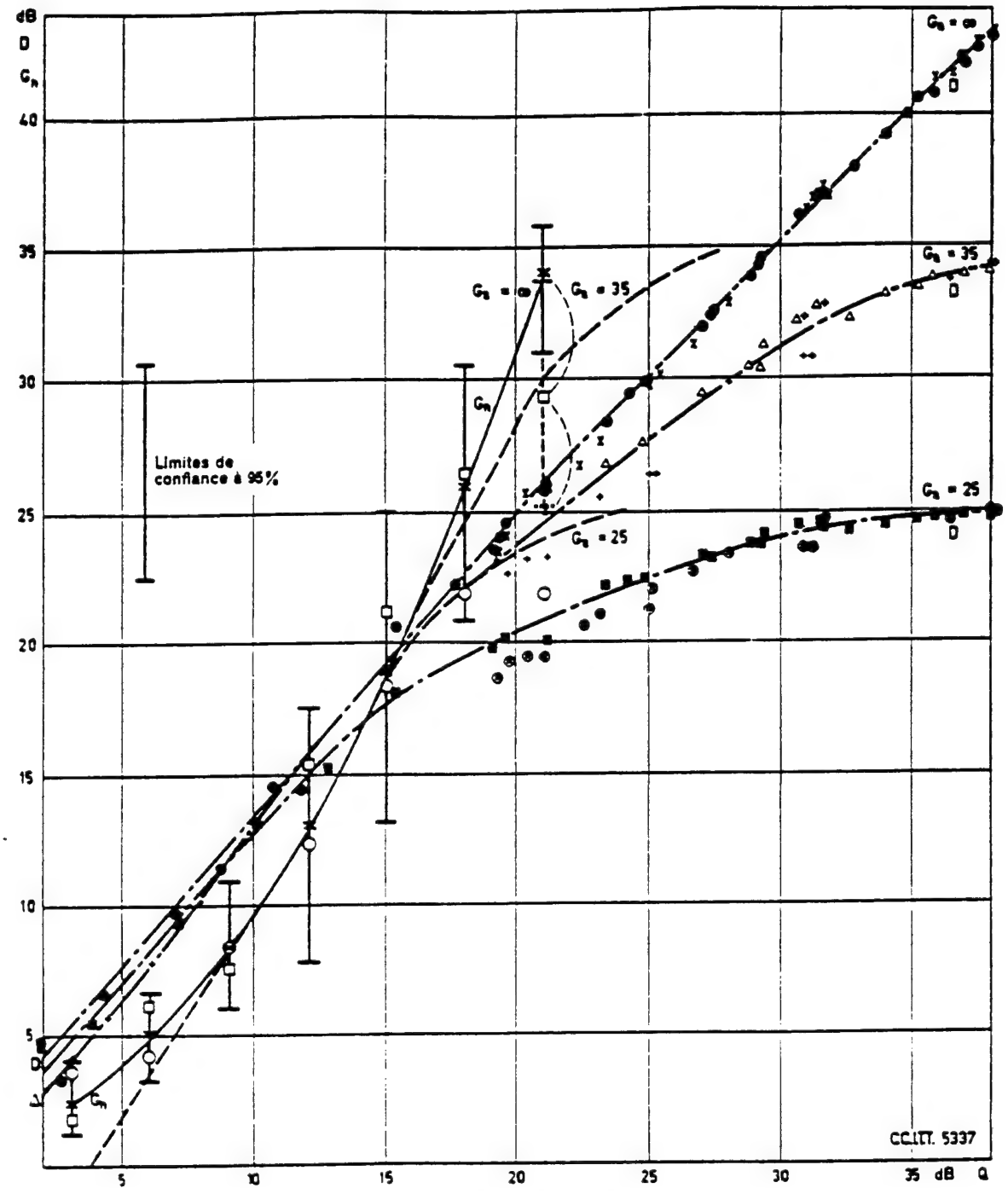


FIG. 5

On saisit physiquement le phénomène de compression en réalisant que lorsque le signal $S(t)$ entre dans la ligne à retard (LAR) la fréquence qui entre la première à l'instant 0 est la fréquence basse f_0, qui met un temps T_0 pour traverser. La fréquence f entre à l'instant $t = (f - f_0)\dfrac{T}{\Delta f}$ et elle met un temps $\dfrac{T}{\Delta f}$ pour traverser, ce qui la fait ressortir T_0 également. Ainsi donc, le signal $S(t)$

FIGURE 5



Courbes adaptées G_a (essais subjectifs) pour $G_a = \infty$ $G_a = 35$dB $G_a = 25$dB

[10] ——— × □ ○

[23] — — — —

Points calculés D (Q, G_a) pour

$G_a = \infty$ $G_a = 25$ $G_a = 35$ dB

● ■ △ – dans la partie montante

× ⊕ – dans la partie descendante

Courbes ——— — — ——— — — D (Q, G_a)

FIGURE 3

TOME V — Question 18/XII, Annexe 6

FIGURE 6

CCITTの概要

沿革

CCITTは、国際電気通信連合（ITU）の四つの常設機関（事務総局、国際周波数登録委員会、CCIR、CCITT）の一つとして、ITUの中でも、世界の国際通信上の諸問題を真先に取上げ、その解決方法を見出して行く重要な機関である。日本名は、国際電信電話諮問委員会と称する。

CCITTの前身は、CCIF（国際電話諮問委員会）とCCIT（国際電信諮問委員会）である。CCIFは、1924年にヨーロッパに「国際長距離電話通信諮問委員会」が設置され、これが1925年のパリ電信電話会議のとき、正式に、「国際電話諮問委員会」として万国電信連合の公式機関となったものである。CCITは、同じく1925年の会議のとき、CCIFと併立するものとして設置された。

そして、CCIFは、1956年の12月に第18回総会が開催されたのち、CCITは、同年同月に第8回総会が開催されたのち、併合されて現在のCCITTとなった。このCCITTは、CCIFとCCITが解散した直後、第1回総会を開催し、第2回総会は、1960年にニューデリーで、第3回総会は、1964年、ジュネーブで、第4回総会は、1968年、アルゼンチンで開催された。

CCIFとCCITが合併したのは、有線電気通信の分野、とくに伝送路について電信回線と電話回線とを技術的に分ける意味がなくなってきたこと、各国とも大体において、電信部門と電話部門は同一組織内にあること、CCIFの事務局とCCITの事務局の合併による能率増進等がおもな理由であった。

CCITTは、上述のように、ヨーロッパ内の国ぐにによって、ヨーロッパ内の電信・電話の技術・運用・料金の基準を定め、あるいは統一をはかってきたので、現在でも、その影響を受け、会合参加国は、ヨーロッパの国が多く、ヨーロッパで生起する問題の研究が多い。たとえば、1960年のCCITT勧告の中で、技術上配慮する距離は約2,500㎞であったが、これはヨーロッパ内領域を想定したものである。

しかしながら、1956年9月に敷設された大西洋横断電話ケーブルは、大陸間電話通信の自動化および半自動化への技術的可能性を与え、CCITTがこの問題を取り上げるに及び、CCITTの性格は漸次、汎世界的色彩を実質的に帯びるに至った。この汎世界的性格は第2次世界大戦後目ざましくなったアジア・アフリカ植民地の独立に伴ってITUの構成員の中にこれらの国が加わり、ITUの中に新しい意見が導入されたことにも起因して、技術面、政治面の双方から導入されてきた。CCITTの汎世界化は、1960年の第2回総会がニューデリーで開催されたことにもあらわれている。この総会までは、CCIT、CCIFのいずれにしろ、アメリカやアジアで総会が開催されたことがなく、CCITT委員長も、ニューデリー総会の準備文書で、この点には注目すべきであるとのべている。

任務

ITUは、全権委員会議、三管庁会議を始めとして、七つの機関をもち、それぞれの機関の権限と任務は国際電気通信条約に明記されている。そこで条約を参照してみるならば、CCITTの任務は、つぎのとおりとなっている。

「国際電信電話諮問委員会（CCITT）は、電信および電話に関する技術、運用および料金の問題について研究し、および意見を表明することを任務とする。」（1965年モントルー条約第187号）

「各国際諮問委員会は、その任務の遂行に当たって、新しい国または発展の途上にある国における地域的および国際的分野にわたる電気通信の創設、発達および改善に直接関連のある問題について研究し、および意見を作成するように妥当な考慮を払わなければならない。」（同第188号）

「各国際諮問委員会は、また、関係国の要請に基づき、その国内電気通信のについて研究し、かつ、勧告を行なうことができる。」（同第189号）

上記第187号と第188号にいわれる「意見」とは、フランス語のAvisを訳したもので、英語では、「勧告（Recommendation）」となっている。CCITT表明する意見は、国際法的には強制力をもたないものであって、この点が、条約信規則、電話規則等各国を拘束する力をもっているものと異なる。もっとも慣は称しても、技術的分野では、電信規則のごとき、各国政府が承認してその内実施する強制規則をもたないので、実際にある機器の仕様を定める場合には、多くの国の意見が統一されたこの「意見」に従わなければ、円滑な国際通信を行なうことができない場合が多い。この意見（または勧告）は、国際通信を行なう場合各国が直面する問題について、具体的意見を表明するもので、たとえば、大陸間ケーブルで大陸間通話を半自動化しようとする場合、その信号方式や取り扱う通話の種類および料金は、どのようにするかを研究して意見を表明する。したがって、CCITTの活動は、つねに時代の最先端を行くもので、CCITTの活動方向は、そのまま世界の国際通信の活動方向であるともいえる。

この意見は、また、電信規則以下のその他の規則のごとく、数年以上の間隔をもって開催される主管庁会議というような大会議の決定をまたなくても表明することができ、また、その改正も容易であるので、現在のように進歩の早い国際通信界では、関係国の意見を統一した国際的見解としては非常に便利である。

FIGURE 7

memorandum

FROM: A.P. Sproggs Research	TO: G.V. Smith Project Planning
TEL: EXTN: 2041	DATE: 1-9-71

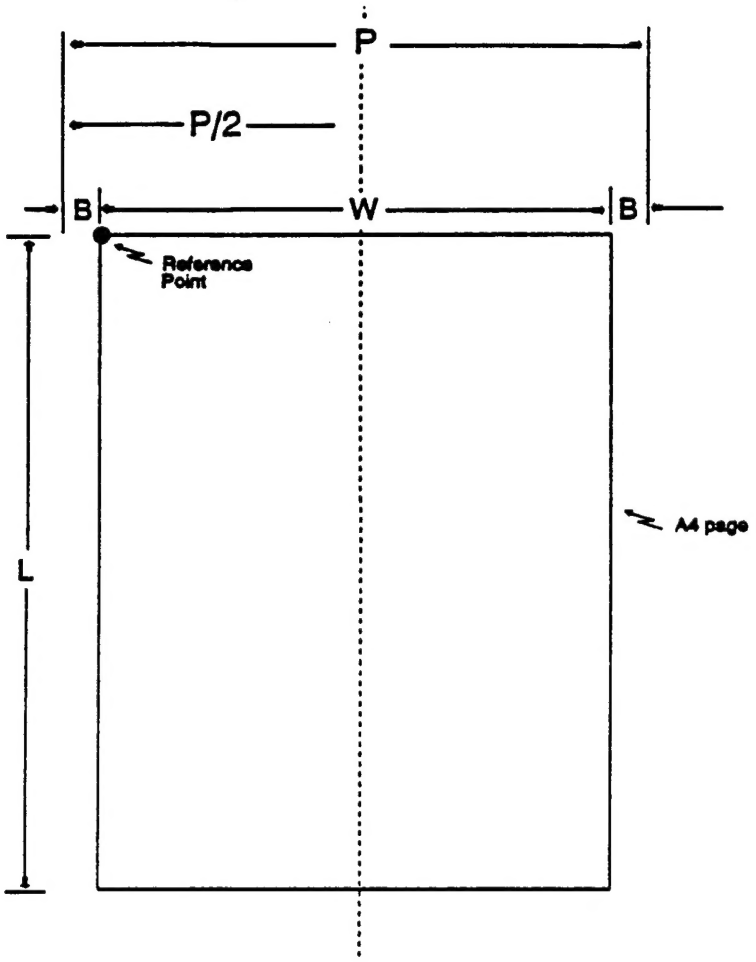
We know that, where possible, data is reduced to alphanumeric form for transmission by communication systems. However, this can be expensive, and also some data must remain in graphic form. For example, we cannot key-punch an engineering drawing or weather map.

I think we should realise that high speed facsimile transmissions are needed to overcome our problems in efficient graphic data communication. We need research into graphics data compression.

Any comments?

Albert.

FIGURE 8



NOTES:

R = Sampling density (pels per 25.4 mm)
P = Total scan line length (pels) = 219.46 mm
W = A4 paper width (pels) = 210 mm
B = Blanking margin (pels)
L = Nominal number of scan lines

R	P	W	B	L	Reference Point
200	1728	1654	37	2339	(38,1)
300	2592	2480	56	3508	(57,1)
400	3456	3308	74	4677	(75,1)
600	5184	4960	112	7016	(113,1)

Figure 9. Scanning geometry

3. IMAGE STORAGE AND RETRIEVAL

The total number of bytes required to store each of the images, as a function of resolution (or sampling density), is shown in Table 1. Note that at 200 pels per 25.4 mm about 0.5 megabytes are required, while at 600 pels per 25.4 mm about 4.5 megabytes are needed. In order to reduce the storage requirements and make DOS diskettes a practical storage media, the data must be compressed.

Table 2 is a list of the 32 compressed files produced by scanning 8 documents at 4 resolutions. The files are stored on 8 DOS diskettes, one document per diskette, with a decompression program stored on each of the diskettes. To retrieve an image from a compressed file, first copy the compressed file to a hard disk and type:

pkunzip <filename> [enter]

The compressed file will be expanded and the result written to the hard disk. Make sure that the hard disk has enough space to contain the expanded image.

Table 1. Image storage requirements

pel density (pels per 25.4mm)	pels per line	scan lines	pels per page	bytes per page
200	1728	2339	4041792	505224
300	2592	3508	9092736	1136592
400	3456	4677	16163712	2020464
600	5184	7016	36370944	4546368

Table 2. Compressed files

DOCUMENT	PEL DENSITY	FILE NAME	UNCOMPRESSED BYTES	COMPRESSED BYTES
Document #1	200	DOC1_200.ZIP	505224	33981
	300	DOC1_300.ZIP	1136592	61770
	400	DOC1_400.ZIP	2020464	96736
	600	DOC1_600.ZIP	4546368	193956
Document #2	200	DOC2_200.ZIP	505224	31166
	300	DOC2_300.ZIP	1136592	53431
	400	DOC2_400.ZIP	2020464	82740
	600	DOC2_600.ZIP	4546368	150728
Document #3	200	DOC3_200.ZIP	505224	48828
	300	DOC3_300.ZIP	1136592	87117
	400	DOC3_400.ZIP	2020464	134523
	600	DOC3_600.ZIP	4546368	254890
Document #4	200	DOC4_200.ZIP	505224	105163
	300	DOC4_300.ZIP	1136592	186133
	400	DOC4_400.ZIP	2020464	283570
	600	DOC4_600.ZIP	4546368	541148
Document #5	200	DOC5_200.ZIP	505224	57283
	300	DOC5_300.ZIP	1136592	100292
	400	DOC5_400.ZIP	2020464	153352
	600	DOC5_600.ZIP	4546368	288427
Document #6	200	DOC6_200.ZIP	505224	35213
	300	DOC6_300.ZIP	1136592	62364
	400	DOC6_400.ZIP	2020464	99982
	600	DOC6_600.ZIP	4546368	197443
Document #7	200	DOC7_200.ZIP	505224	119462
	300	DOC7_300.ZIP	1136592	209547
	400	DOC7_400.ZIP	2020464	316710
	600	DOC7_600.ZIP	4546368	242113
Document #8	200	DOC8_200.ZIP	505224	47752
	300	DOC8_300.ZIP	1136592	83438
	400	DOC8_400.ZIP	2020464	126685
	600	DOC8_600.ZIP	4546368	234532